

The Winter Lake – Lac de Gras regional mapping project, central Slave Province, District of Mackenzie, Northwest Territories

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Abstract

Located 250 km north of Yellowknife, the map area (10 800 km²) includes parts of the three volcano-sedimentary domains (Point Lake-Contwoyto Lake, Yellowknife-Beaulieu River and Lac de Gras-Courageous Lake) that have produced most of the mineral wealth of the Slave Province. A reconnaissance this summer expanded the area of known supracrustal rocks, found structural and stratigraphic evidence of potential granitoid basement, confirmed the lack of mappable contact aureoles around major "plutons" in the Lac de Gras domain, and documented interlayering of potential basement and supracrustal rocks that is tentatively attributed to thrusting during main phase deformation.

A better understanding of the origin, evolution and economic potential of the region will be obtained during the next three field seasons with a combination of 1:250 000 scale mapping, detailed mapping of the Courageous Lake volcanic belt and the western supracrustal domain, and topical studies in geochronology, metallogeny, petrology, and geophysics.

Résumé

Situé à 250 km au nord de Yellowknife, la région cartographiée (10 800 km²) comprend des portions des trois domaines volcano-sédimentaires (Point Lake-Contwoyto Lake, Yellowknife-Beaulieu River et Lac de Gras-Courageous Lake) qui ont généré la majeure partie de la richesse minérale de la province des Esclaves. Un levé de reconnaissance effectué cet été a permis d'élargir la superficie de roches supracrustales connues, de découvrir les indices structuraux et stratigraphiques de la présence possible d'un socle granitoïde, de confirmer l'absence d'auréoles de contact pouvant être cartographiées autour de grands «plutons» dans le domaine de Lac de Gras, et de décrire l'interstratification de roches appartenant peut-être au socle et de roches supracrustales, que l'on attribue provisoirement à un charriage survenu pendant la principale phase de déformation.

On parviendra à une meilleure compréhension de l'origine, de l'évolution et du potentiel économique de la région pendant les trois prochaines saisons d'études de terrain, en combinant la cartographie à l'échelle de 1/250 000, la cartographie détaillée de la zone volcanique de Courageous Lake et du domaine supracrustal occidental, et les études de thèmes en rapport avec la géochronologie, la métallogénie, la pétrologie et la géophysique.

INTRODUCTION

A 1:250,000 scale mapping project that will cover 10,800 km² during the next three field seasons has been initiated. The objective is to better understand the origin, evolution and economic potential of the region by upgrading the bedrock geology of the east half of the Winter Lake (NTS 86A) and west half of the Lac de Gras (76D) map areas.

Located 250 km north of Yellowknife (Figure 1), the area includes parts of the Point Lake – Contwoyto Lake, Yellowknife – Beaulieu River, and Lac de Gras – Courageous Lake supracrustal domains. The richest gold mines in the Slave Province have been found in one or other of these volcano-sedimentary sequences, and significant massive sulphide deposits occur north of Point Lake. The project will provide an opportunity to compare and contrast the rock types, mineral deposits, and history of deformation, magmatism and metamorphism in all three domains. As presently defined, the volcano-sedimentary elements are separated by relatively poorly-known gneissic, migmatitic and massive granitoid rocks that underlie about sixty percent of the area. These rocks are part of the extensive "pink areas" in the Slave Province that, until recently, have received relatively little attention even though they are a key part of any reconstruction of the tectonic evolution of the Slave Province. As a result, they are *terra incognita* as far as mineral potential is concerned. A principal objective of this project is to redress this imbalance. As bedrock mapping proceeds, it would be useful to upgrade knowledge of surficial geology in the Winter Lake – Lac de Gras area. This information is important for mineral exploration, for planning and constructing roads and for study of the environmental impact of development.

The project began this summer with a three week reconnaissance on "Noname" Lake, Lake Providence, and Courageous Lake (Figure 1). Field work combined brief visits to previously-mapped outcrops with regular traverses that represent the start of systematic mapping. Information collected was stored and processed using a combination of FIELDLOG (Brodaric and Fyon, 1989) and AUTOCAD. Preliminary work also began on several of the special studies that will be linked, scientifically and logistically, to the regional mapping project. Specifically, samples were collected for paleomagnetism of basic dykes, for geochronology and for a gravity and aeromagnetic study aimed at determining the three dimensional shape of supracrustal and plutonic units.

RESULTS

The reconnaissance confirmed the importance of the Winter Lake – Lac de Gras area with respect to several fundamental aspects of Slave Province geology. These include: a) occurrence of sialic basement to the Yellowknife Supergroup supracrustal rocks; b) extension of economically important metasedimentary and metavolcanic rocks into high grade gneissic and migmatitic terranes; c) heat source for regional metamorphism; d) role of thrusting and transcurrent shear zones; e) metallogeny of gold and base metals. Bearing in

mind the preliminary nature of the work so far, this report summarizes the implications of some of the observations made this summer.

The provisional outline of litho-structural domains (Figure 1) is derived from earlier regional mapping of the west (Fraser, 1958, 1969) and east (Folinsbee, 1949) halves of the area. The subdivision is determined by the predominant rock types in each domain. Homogeneous plutons have not been singled out. The western supracrustal belt is the southern extension of the Point Lake – Contwoyto Lake supracrustal succession and the eastern metasedimentary rocks are part of the extensive Lac de Gras supracrustal domain. The northern limit of metasedimentary rocks continuous with the Yellowknife supracrustal domain and the northern end of the Beaulieu River metavolcanic belt occur in the southwest corner of the map area. The northern metasedimentary migmatite domain is more of a composite element than the others. It is a transitional domain in that the high grade metasedimentary rocks link the Point Lake – Contwoyto Lake and Lac de Gras supracrustal domains. Furthermore, the occurrence of bodies of granitoid complex make the northern domain transitional between the main mass of granitoid complex to the south and the major Point Lake – Contwoyto Lake supracrustal domain to north of the map area.

1) Rock Types and Stratigraphy

In the northern domain (Figure 1), migmatite and gneiss in Fraser's (1969) Unit 4 and in Folinsbee's (1949) Unit 5 were found to be derived from both sedimentary and plutonic protoliths. The distinction is important for two reasons. First, the metamorphic transformation of supracrustal rocks to migmatite or gneiss does not necessarily reduce their economic potential. Therefore, the area of interest for mineral exploration can be extended into high grade terrains (e.g., gold-bearing, Lupin-type iron formation in the sillimanite and migmatite zones in northeastern Slave (Thompson et al., 1986)). Secondly, granitoid rocks can be transformed as well to migmatite or gneiss by anatexis, injection of melt, and metamorphic segregation before, during, or after main phase deformation. Such rocks form the crystalline basement to supracrustal rocks in, for example, the Alpine, Cordilleran and Wopmay Orogens. Distinction of metasedimentary and granitoid protoliths in gneissic and migmatitic terranes may be a key element in determining the distribution of sialic basement to the Yellowknife Supergroup in the Slave Province.

In his compilation of Slave Province geology (McGlynn, 1977) included a large part of the granitoid complex underlying the western half of the map area in a unit identified as "potential" or "in part" basement. East of Noname Lake volcanic belt, most of the granitoid complex is distinctly heterogeneous. From one outcrop to the next and commonly within a single outcrop, structures vary from massive to foliated to migmatitic granitoid and gneiss while various modal combinations of biotite, quartz, plagioclase, and potassium feldspar range from granite to granodiorite. Hornblende-bearing tonalitic or dioritic phases are less common.

East of the west arm of Courageous Lake (Figure 1), metamorphosed gabbro dykes with chilled margins cut across granitoid complex to form metagabbro sills in the mafic metavolcanics (Moore, 1956). Interpreted by Dillon-Leitch (1981) as related to volcanic magmatism, the metagabbro indicates the granitoid rocks are older than the volcanic belt. Reconnaissance structural and stratigraphic data (see below) are consistent with McGlynn's attribution but further

mapping and detailed geochronology are required to determine how much of the granitoid complex is basement to the Yellowknife Supergroup.

Thinly-layered, greenish-grey- to black-weathering amphibolitic gneiss a few tens of metres thick was found in the northern metasedimentary migmatite domain. Not shown on Folinsbee's map, the gneiss occurs between pelitic

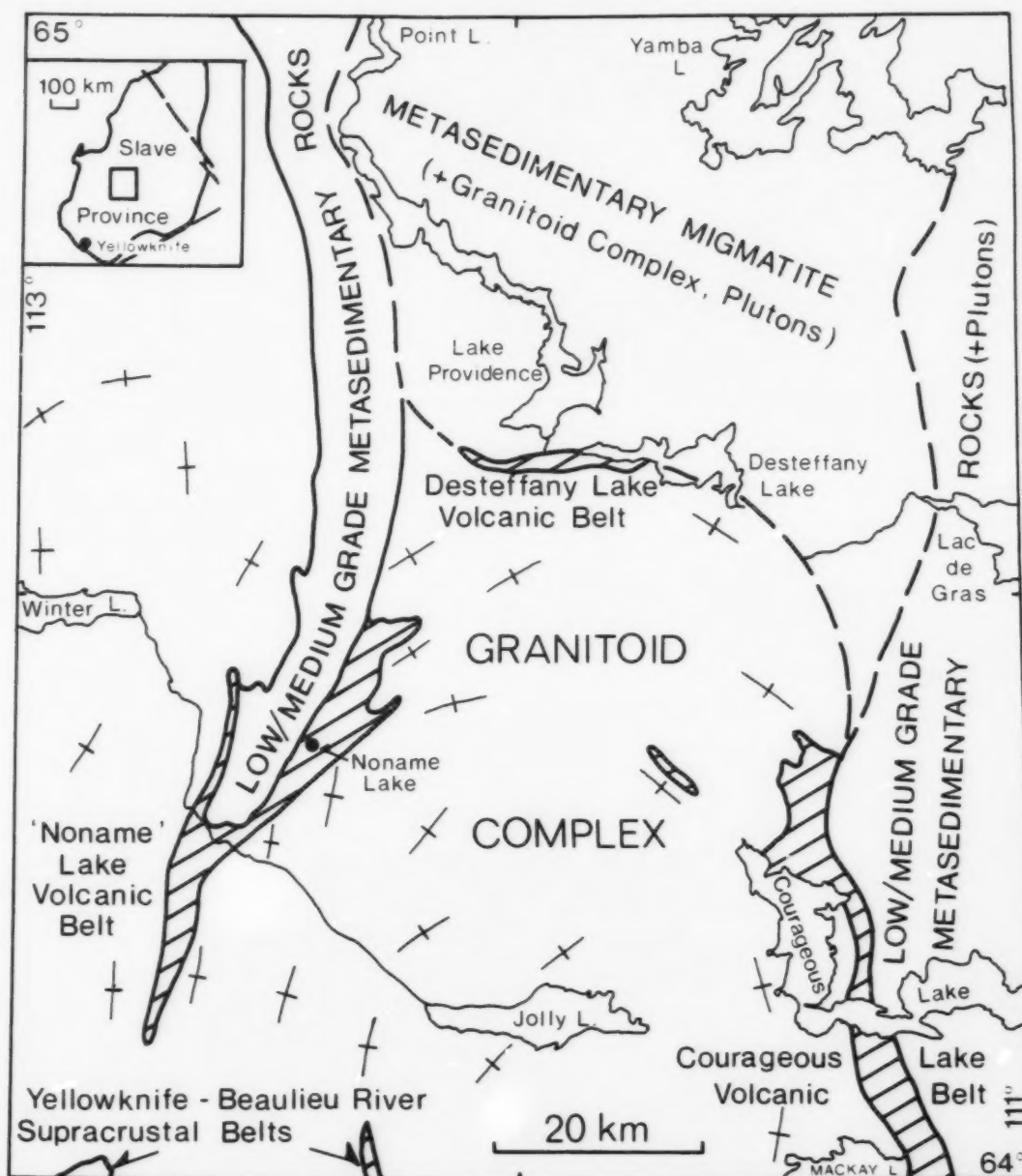


Figure 1. Provisional lithostructural elements of the Winter Lake - Lac de Gras map area. The subdivisions reflect the dominant lithology in each domain. Note that parts of the Point Lake - Contwoyto Lake, Lac de Gras, and Yellowknife - Beaulieu volcano-sedimentary successions are present.

metasedimentary rocks and foliated, migmatitic granitoid and quartzofeldspathic gneiss that resemble the rocks in the granitoid complex to the south (Figure 1). Both amphibolitic gneiss and metasedimentary rocks are considered to be part of the Yellowknife Supergroup. Walking up the gently northward-dipping structural section, the kilometre scale sequence consists of granitoid complex, amphibolitic gneiss, metasedimentary rocks, amphibolitic gneiss, granitoid complex, metasedimentary rocks, amphibolitic gneiss, mylonitic quartzofeldspathic rocks and foliated granitoid. The "stratigraphy" and rock types are strikingly similar to that mapped in the eastern (west of Healey Lake, Henderson et al., 1982; Henderson and Thompson, 1982) and northeastern (east of Bathurst Inlet; Thompson et al., 1986; Thompson, 1986) Slave Province where a thin metavolcanic unit separates metamorphosed Yellowknife sedimentary rocks from granitoid migmatites considered to be, at least in part, basement to the supracrustal rocks.

There are marked differences between the Noname Lake and Courageous Lake volcanic belts. Metavolcanic rocks in the western belt are basic to intermediate in composition and are commonly pillowed. Volcaniclastic units are prominent. Felsic rocks were not observed and Fraser (1969) did not mention them. The volcanic rocks are intimately associated with sills of metagabbro that were considered by Fraser to be related genetically to volcanism. At the western contact of the metavolcanic rocks with metasedimentary rocks, the metavolcanic rocks are interlayered with a spectacular volcanic and plutonic pebble metaconglomerate (Fraser, 1969; Rice et al., 1990). Within the volcanic succession east of the conglomerate, two zones (600 and 300 metres thick) of quartz-rich and pelitic metasedimentary rocks were found that are similar to those included in the Beniah Formation (Covello et al., 1988; Roscoe et al., 1989) 100 km to the south. The eastern contact with the granitoid complex was covered where traversed but the nearest exposed supracrustal rocks are relatively highly strained.

In contrast, felsic volcaniclastic rocks and flows and quartz-feldspar porphyry are a major component of the Courageous Lake volcanic belt (Folinsbee and Moore, 1950; Moore, 1956; Dillon-Leitch, 1981). Within the volcanic pile metasedimentary rocks are limited to a thin pelitic unit a few metres thick and granitoid pebble-bearing metaconglomerate is restricted to a single outcrop (Dillon-Leitch, 1981). Metamorphosed synvolcanic gabbro dykes described above indicate the granitoid complex to the west is older than the Courageous Lake volcanic belt (Moore, 1956).

2) Metamorphism

The widespread occurrence of andalusite, sillimanite, cordierite at medium grade, and an abundance of metasedimentary migmatite with cordierite in the leucosome indicate that low-pressure, greenschist to upper amphibolite facies conditions of regional metamorphism were attained. Porphyroblasts of cordierite and andalusite overgrowing the principal foliation, sillimanite lineations, minor folds cut by anatectic leucosome that itself has been folded and sheared document the overlap in time of metamorphism and

deformation. Limited distribution of garnet is typical of the generally iron-poor compositions of metasedimentary rocks in the Slave Province (Thompson, 1978). On the other hand, at two localities in the Noname Lake volcanic belt, the abundance of garnet in metasedimentary rocks interlayered with mafic metavolcanics indicates the occurrence of more iron-rich compositions in this association.

At one locality within the easternmost of the two sedimentary sequences in the Noname Lake volcanic belt, metamorphic grade jumps from upper greenschist to upper amphibolite facies across a 100 metre wide covered interval. Neither of the two outcrops is strongly deformed. The sudden increase in grade occurs across the strike of the layering and principal foliation in the belt. West of Lake Providence (Figure 1), there appears to be a larger scale telescoping of metamorphic grade between the lower grade rocks in the north-trending supracrustal belt and the metasedimentary migmatites of the northern domain to the east. Unusually steep or discontinuous metamorphic gradients in the area will be studied in considerable detail because they may be the result of tectonic breaks along major syn- to post-metamorphic shear zones.

Metamorphic field relations in the Winter Lake - Lac de Gras area indicate the abundant granitoid rocks are probably not the principal source of heat for regional metamorphism. For example, in the eastern supracrustal domain (Figure 1), the cordierite isograd cuts across contacts between granitoid and metasedimentary rocks (see Folinsbee, 1949; Dillon-Leitch, 1981). Furthermore, the prominent plutons north of Courageous Lake in eastern metasedimentary domain that lack mappable metamorphic aureoles in adjacent greenschist grade phyllite and metagreywacke (Folinsbee, 1949) were found to be themselves metamorphosed and variably-deformed. The decrease in metamorphic grade southward across the northern metasedimentary domain and Desteffany Lake volcanic belt (Figure 1) is consistent with the granitoid complex being basement, or at least pre-metamorphic, but not consistent with it being a major source of heat. Finally, if the granitoid complex, the predominant unit in the western half of the map area, was a major source of heat, it is surprising that only greenschist grade conditions were attained in the central part of the Noname metavolcanic belt. Metamorphic data in the map area indicates that a significant proportion of the granitoid rocks may be older than the metamorphism and, therefore, contrary to Folinsbee's (1949) suggestion they are not likely to be a major source of heat during regional metamorphism. The map area will provide an opportunity to test an alternative hypothesis that both granitoid magmatism and low pressure metamorphism are the product of moderate overthickening of previously thinned sialic crust and associated sedimentary rocks (Thompson, 1989).

3) Structure

Three lines of structural evidence suggest sialic basement may be a component of the granitoid complex. At the regional scale (Figure 1), the occurrence of the major volcanic belts along the contact between granitoid complex and

metasedimentary rocks is similar to the situation elsewhere in the Slave Province where granitoid basement to the Yellowknife Supergroup has been confirmed by geochronology (Frith et al., 1977; Henderson, 1985; Easton, 1985). Secondly, the angular discordance between gneissic layering and foliations in the granitoid complex and the stratigraphy and principal foliation in adjacent supracrustal rocks may be only a major structural discontinuity but the discordance is consistent also with a basement/cover relationship and a longer, more complex history in the granitoid complex. The discordance is 20 degrees with respect to the underlying Noname volcanic belt and 90 degrees with respect to overlying amphibolitic gneiss and metasedimentary rocks east of Lake Providence. Thirdly, refolded, kilometre-scale interlayering of granitoid complex, amphibolitic gneiss and metasedimentary rocks near Lake Providence implies all three units existed before main phases of crustal thickening began. This is consistent with granitoid complex as basement to the supracrustal sequence or as an early (synvolcanic?) intrusive phase. Clearly, while the existence of basement is not yet proven, it remains a distinct possibility.

The role of thrusting in the deformation history of the Slave Province remains controversial in part because repetition of the stratigraphy is difficult to prove in the absence of continuous and extensive marker horizons like quartzite or marble. The repetition of the "stratigraphy" (granitoid complex-amphibolitic gneiss-metasedimentary rocks) near Lake Providence is, therefore, very interesting. If thrusting is responsible for the moderately-dipping structural sequence there, the process may also be a factor elsewhere in the area, for example, in the origin of the interlayering of mafic metavolcanic rocks, metagabbro and low grade metasedimentary sequences within the Noname Lake volcanic belt.

There is abundant evidence of shear strain in the Winter Lake - Lac de Gras area. Narrow zones of grain-size reduction parallel straight contacts within and along the boundaries of supracrustal belts. Metamorphic grade in the zones ranges from greenschist to middle amphibolite facies. Sheared-off leucosomes cutting shear zones that displace older leucosomes indicate shearing occurred at the highest grade as well. Telescoping of metamorphic gradients in the western half of the area may be the result of thrusting, extensional faulting, transcurrent shear, or some combination of these processes. Straight topographic lineaments like the one along the southeast boundary of the Noname Lake volcanic belt and some narrow linear aeromagnetic anomalies are candidates for late brittle faults.

4) Economic Geology

The distribution of supracrustal rocks with potential economic interest has been extended and differences between supracrustal domains documented. While knowledge of such differences may eliminate a domain with respect to one kind of exploration target, it may be very favourable for another target. For example, does the absence of significant discoveries in the Noname Lake volcanic belt mean the rocks

are barren or, given the clear lithologic differences with respect to the Courageous Lake volcanic belt, has just one of several potential exploration targets been eliminated? The metasedimentary rocks in the northern and eastern domains (Figure 1) appear to be more arenaceous and less pelitic than the Yellowknife Supergroup metasedimentary rocks east of Bathurst Inlet that contain Lupin-type gold-bearing iron formation (Thompson et al., 1986; Thompson, 1986). Is the apparent absence of iron formation in the Winter Lake - Lac de Gras area a reflection of a sedimentary depositional environment that favoured a different kind of ore deposition? Are there favourable areas within the northern and southern parts of the Courageous Lake belt that may be expected to contain gold deposits similar to those in the central part? What is the potential for the discovery of base and/or precious metal synvolcanic ores? These are the kinds of questions that this project with its combination of regional mapping and metallogenic studies is designed to answer.

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